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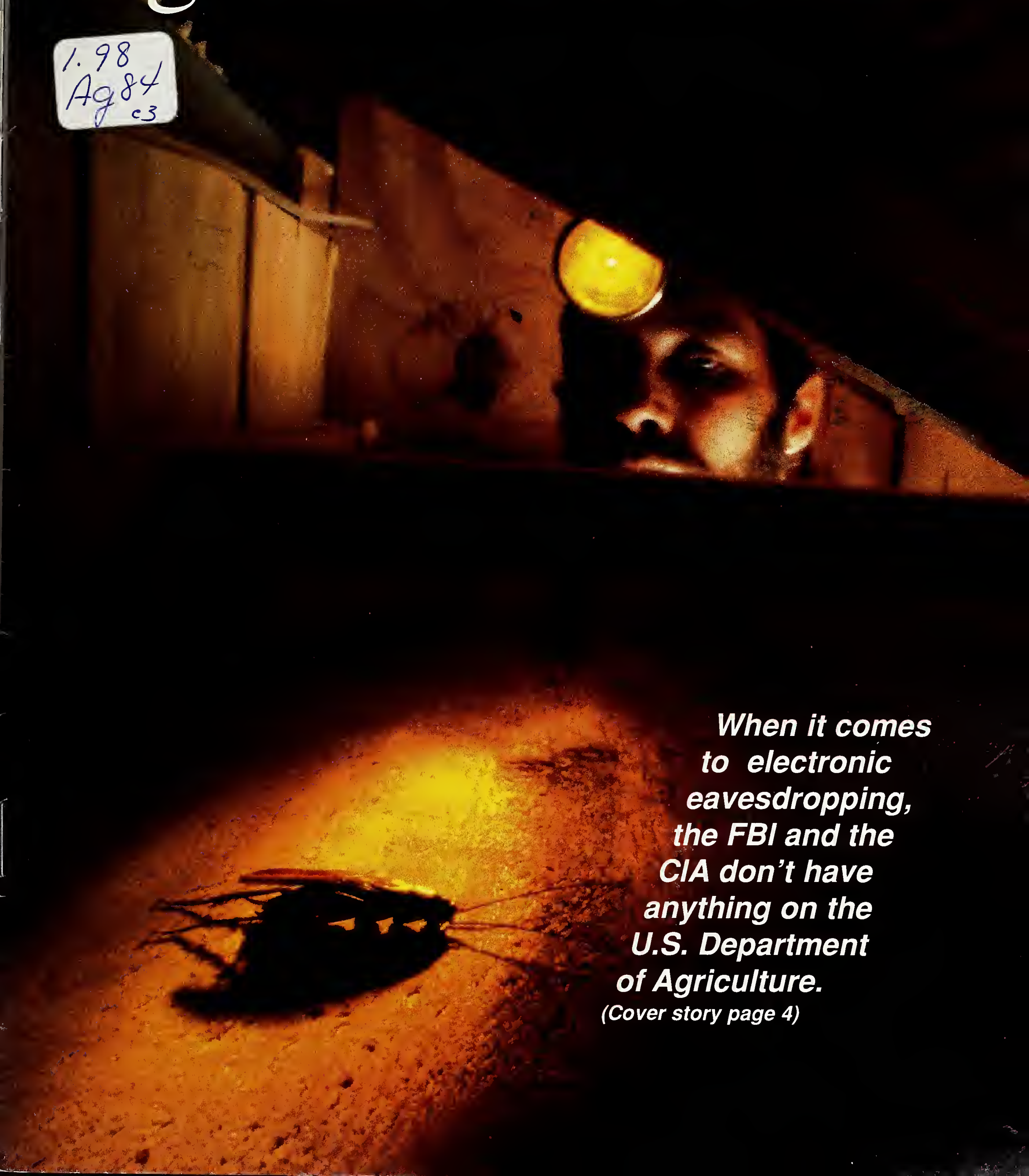
Agricultural Research



When it comes to electronic eavesdropping, the FBI and the CIA don't have anything on the U.S. Department of Agriculture.

(Cover story page 4)

The Cockroach Controversy

Even cockroaches have their constituency. Today there's a school of thought that suggests scientists ought to let up on the repulsive insects.

The reasoning goes that unlike blood-feeding arthropods—mosquitoes, ticks, and fleas, for example—roaches are only incidental disease transmitters. Thus, the roach revisionists argue, the risks that attend cockroach control may outweigh the benefits to be gained by maintaining a roach-free home.

Scientists at the U.S. Department of Agriculture's Imported Fire Ant and Household Insects Research Laboratory in Gainesville, Florida, remain skeptical. They've been studying roaches in Gainesville since the 1940's, but are not yet ready to signal detente. It is true that cockroaches have never been irrefutably incriminated in the natural transmission of pathogenic organisms to man, but there's plenty of circumstantial evidence to tie the roach to cases of typhoid fever and other diseases caused by *Salmonella* bacteria. They've also been implicated as carriers of *Clostridium perfringens, Staphylococcus aureus,* and polio.

Roaches are notorious scavengers. They eat contaminated food and waste, then carry microorganisms in their digestive tracts, releasing them on the surfaces they contact. Release occurs through vomiting, excreting wastes, and laying eggs on human food.

Besides carrying disease, roach infestations can also trigger allergic reactions in some people. An immunologist at Mount Sinai Hospital in Chicago has found that 58 percent of asthmatic adults and 69 percent of asthmatic children have allergic reactions to cockroaches. These range from skin swelling and redness to full-fledged asthma attacks.

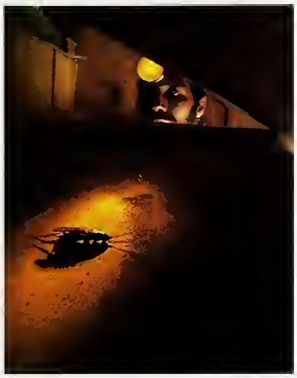
Yet another reason the insects are traditionally despised is that cockroach infestations seem to expand at Malthusian rates; a female roach can produce up to tens of thousands of offspring a year. In one study, Agricultural Research Service scientists scoured low-income apartments in Florida and turned up 20,000 cockroaches—in each apartment!

There's also an esthetic dimension to the matter of food cleanliness. William E. Currie, a pest management specialist with the Environmental Protection Agency, drives home the queasy point when he describes "roaches crawling out of the drain, across the counter, and onto the cream pie." Perhaps this image underlies the fact that attempts to control the cockroach are the largest expenditure for a single pest in the United States.

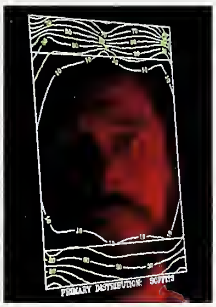
Compounding Americans' concern about the cockroach is the recent arrival of a most unwanted—and unnerving—alien, the Asian cockroach. Unlike other roach species, the Asian cockroach is attracted to light and does not flee when people enter the room. It is adapted to life indoors or outdoors. The new species is omnivorous, feeding on mulch, dead insects, animal droppings, carrion, and even honeydew produced by ants on citrus.

This issue of *Agricultural Research* spotlights two efforts to control the familiar household pest. *Cockroaches in the Attic* describes the latest in hi-tech snooping operations, geared to gathering information that suggests ways to construct roach-free houses. And *New Cockroach, Ant Insecticide* describes a radically effective new roach bait, sulfluramide, which scientists chanced on while testing another compound. —By **Regina Wiggen**, *ARS.*

Agricultural Research



The smokybrown cockroach, a common household invader in a third of the United States, is spotted by research entomologist Richard Brenner. Using a filtered yellow light with a wavelength of about 500 nanometers, Brenner observes roach behavior without disturbing them. Photo by Barry Fitzgerald. **(K-3272-3).**



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DEPARTMENTS

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BARRY FITZGERALD

Entomologist Richard Brenner studies a computer-drawn map of cockroach distribution in the experimental attic. (K-3271-13)

Cockroaches in the Attic

It takes a lot of technology to sound out the secretive critters.

USDA's Agricultural Research Service is doing a lot of "bugging" of its own in Gainesville, Florida.

With the idea that the more you know about an enemy the more likely you are to defeat it, ARS is using electronic surveillance to figure out just what makes the cockroach tick.

Often considered a sign of unsanitary conditions, the cockroach evokes both fear or disgust wherever it's seen.

At least that's how Richard J. Brenner, an entomologist at ARS' Insects Affecting Man and Animals Research Laboratory, describes a pest that has been around since the days of dinosaurs.

It's a hardy insect. The cockroach has survived literally every natural disaster and change, as well as the traps, poisons, and repellants that man has thrown against it.

Some 4,000 species of cockroach are known to scientists. Of these, only about 50 are considered pests. Brenner estimates that nationwide, nearly $1.5 billion is spent each year to apply pesticides against cockroaches.

Because long-term solutions are the goal of the Gainesville lab, some sophisticated methods have been devised to study cockroach behavior.

"We really want to know everything about these roaches, from the time they hatch to the time they die—where they go, what they do, and what variables govern their activity," Brenner says. "That means we have to understand their behavior in the context of their environmental surroundings.

Spying on cockroaches' private lives began soon after ARS and Air Vent, Inc., of Peoria, Illinois, signed a research and development agreement in February 1988 to find out how building construction affects cockroach infestation.

Air Vent built a garage-sized structure for the Gainesville lab with an attic divided in half. Cockroach behavior could be compared under different conditions in each of the two sections.

Brenner placed electronic sensors at strategic points inside each attic to determine when, where, and why a cockroach moves from one area of a

BARRY FITZGERALD

About 100 sensors and probes set at various locations in the attic, including the filtered soffet vent that entomologist Richard Brenner is checking, give continuous, precise measurements on cockroach movements and environmental conditions. (K-3264-6)

home to another. "What we really need are continuous, precise measurements—exact measurements on their habitats," Brenner says. "That really puts us into the electronic mode."

Monitoring cockroaches 24 hours a day without the electronic system would have required round-the-clock staffing involving probably 12 people, Brenner says.

Some sensors measure temperature and humidity of air in the test attics. Others measure temperatures inside insulation and in the wood, while still

"We really want to know everything about these roaches, from the time they hatch to the time they die—where they go, what they do, and what variables govern their activity."

Richard Brenner, research entomologist

others check airflow patterns. A telephone hookup enables the scientists to take sensor readings and transmit them to computers even at distant locations.

Recently, Brenner was at ARS' Beltsville, Maryland, headquarters for a meeting where he demonstrated how the system works. By dialing a telephone number at the attic, he obtained a complete readout of the latest information collected by the sensors.

Brenner believes in taking his work home with him too. He placed probes in the attic of his own house to gather information about conventional residential construction.

He also placed sensors in a tree hole in his yard. The environment

BARRY FITZGERALD

Nearly ready to release his jarful of roaches, biological technician David Milne makes a final check of his data logger. He won't disturb the cockroaches—they're blind to this range of the spectrum. (K-3268-2)

inside a tree hole is ideal for cockroach survival. Among all locations of the sensors, scientists can now compare cockroach behavior in various settings.

The electronic surveillance has shown that a cockroach's behavior changes throughout the day. The insects tend to be inactive during the day, beginning their movement in the attics at night. The sensors are helping researchers understand why cockroaches prefer the nightlife and under what conditions they'll venture out during the day.

Right: Entomologist Richard Brenner checks a cockroach bait station before David Milne places it in one of the test building's filtered soffet vents. The station adjusts to changing temperature and humidity to provide the most attractive bait to cockroaches. (89CN1506)

BARRY FITZGERALD

Below: Both cockroach movement and microclimate sensors are inspected by Richard Brenner. Data from the movement sensors is plotted on a contour map to show areas commonly inhabited by cockroaches in the test attic. (K-3270-7)

BARRY FITZGERALD

Airflow was shown to reduce cockroach survival. Cockroaches become inactive at temperatures of 53°F or lower.

Brenner says these cooler temperatures don't kill cockroaches but rather makes them sit still until things warm up.

Cockroaches thrive in areas of stagnant air and high humidity. "Anything other than that tends to dry them out," he says.

But while the Gainesville lab can monitor cockroach movement in the attic under specific environmental conditions, Brenner says there isn't currently a way to determine if the movement sensors are picking up from 1 or 500 cockroaches.

Visual spying on cockroaches could help researchers understand complete behavior, but again the amount of labor pushes up the cost of the studies. So scientists at the lab hope to install a video image analyzer to track the number of cockroaches that move under specific conditions.

Brenner says a cockroach behaves differently in a group than it does when alone, so it's essential to study these interactions.

It will be necessary to put a unique mark on each cockroach in the test attic so the image analyzer could recognize each and record its travels, says Brenner.

With that information, the lab could build profiles on cockroach behavior. The equipment could tell researchers how and when a cockroach moves from one point to another and which path it chooses and what areas are avoided.

By altering the attic's environmental conditions, researchers may determine what factors control cockroach movement.

New Cockroach, Ant Insecticide

It's the Trojan horse trick for cockroaches and ants. A bit of food—left out for a scavenging pest to find—is carried back to the nest where it spreads disaster for all.

That is the whole idea behind a new slow-acting insecticide developed by three Agricultural Research Service scientists.

"In practice," says retired ARS entomologist Clifford S. Lofgren, "the insecticide, sulfluramid, is coated on a bait that household ants share with nestmates, killing the whole colony, including the queen. Cockroaches, of course, don't live in true nests, but they're social enough that this pyramid effect will kill their neighbors too." Lofgren is based in Gainesville, Florida.

In the United States, he says, consumers spend vast amounts of money to control household ants and roaches. Fire ants alone cause up to $200 million worth of damage annually in medical costs and agricultural losses.

Sulfluramid was discovered when it was used as a wetting agent to coat baits with a potential insecticide for fire ants. "When the ants were killed not only by the test bait but also by a nontoxic control bait coated only with the wetting agent, we realized we had stumbled onto a new class of compounds for controlling them," Lofgren says.

"The insecticide killed 90 percent of household ants and roaches in laboratory tests. Another pest, the imported fire ant, also had an equally high mortality rate in lab tests," he says. The fire ant is a stinging and mound-building pest established in 10 southern states.

Results of preliminary studies indicate that sulfluramid works on domestic termites also. Other scientific reports show it to be highly toxic to Formosan termites, a destructive pest newly invading this country.

Recently approved by the U.S. Environmental Protection Agency for use against household ants and roaches, sulfluramid is marketed by Griffin Corp., of Valdosta, Georgia, under an exclusive license from the U.S. Department of Commerce.

"The company plans to apply to EPA to register the insecticide for use against imported fire ants at recreation areas such as golf courses and ball fields, at utility companies and factories, and along roadways," says Allan Las, the company's business manager for insecticides. It is not as yet approved for home use.

Over 60 years ago, Lofgren says, the imported fire ant was discovered in Mobile, Alabama, far from its native home in central South America. It has since spread to Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. It has also colonized Puerto Rico, and in the last 2 years, isolated infestations have been discovered and eradicated from Arizona and California.—By **Vincent Mazzola,** ARS.

For further information, contact Robert K. Vander Meer or David F. Williams in USDA-ARS Imported Fire Ant and Household Insects Research, P.O. Box 14565, Gainesville, FL 32604 (904) 374-5920. Patent Application Serial No. 06/785,856 "A Method for the Control of Insects." ◆

Once scientists determine the conditions that cockroaches need to thrive, Brenner says it may be possible to manipulate the environment around the home to repel them.

Not only is the outside environment a factor, but so is the construction of a building. For example, location of eave vents can greatly affect airflow and humidity in the attic. Also, improper roofing practices virtually guarantee a moisture problem that will allow cockroaches to thrive.

The research is expected to expand from the attic to the walls of the building next year, Brenner says.

Some species, such as the German cockroach, primarily inhabit walls. Using the same set of sensors, scientists can learn why walls serve not only as excellent homes for some cockroaches, but also as highways to attics for others.

"The bottom line is safer, more effective means of controlling cockroaches and ultimately preventing infestations," Brenner says.—By **Bruce Kinzel**, ARS.

Richard J. Brenner is in the USDA-ARS Insects Affecting Man and Animals Research Laboratory, P.O. Box 14565, Gainesville, FL 32604 (904) 374-5937 ◆

World's Friendliest Biotechnology Lab

BARRY FITZGERALD

BARRY FITZGERALD

Upper left: Horticulturist David Forehand uses a microscope to examine embryonic carrot cells. (89CN1522-9) **Above: Pineapples growing in EPCOT Center's Tropic Greenhouse were produced from tissue culture in the biotechnology laboratory.** (89CN1524-5)

Ten million people a year now get a closeup look at tissue culture and biotechnology in action.

Tour boats take 40 people at a time through the first working plant biotechnology laboratory completely open to the public—as part of the "Listen to The Land" tour of The Land pavilion at Walt Disney's EPCOT Center in Lake Buena Vista, Florida. The lab opened October 7, 1988.

The laboratory, cooperatively developed by the Agricultural Research Service, Kraft, Inc., and Walt Disney World, gives many people their first look at how biotechnology is creating higher quality crops, with characteristics such as improved pest resistance, drought tolerance, longer shelf life, or better nutritional value.

As the boats enter the lab viewing area, visitors see a time-lapse film of carrot cells developing into carrot embryos. Then they observe technicians, working just a few feet from the passing boats, carrying out the steps to regenerate whole pineapple, peanut, vanilla, strawberry, carrot, and potato plants from cells or sections of leaf tissue.

Containers filled with strawberry or pineapple plantlets move back and forth on shaker tables to aerate the liquid media while 12-gallon bottles with thousands of pre-embryonic plant cells rotate constantly.

Over 1 million plantlets are nurtured at a time in the 500-square-foot lab.

Thirty-five-inch video screens allow visitors to peer through microscopes along with researchers as they go about the delicate processes of altering and propagating plants.

Use of cloning and tissue culture techniques are not new to The Land, says Henry Robitaille, agricultural manager of The Land. Tissue culture has been used behind the scenes since the pavilion opened in 1982 to help supply the exhibit growing areas with plants that are normally very difficult or slow to grow from seed.

As they mature, cloned plants are transferred to other exhibit areas, with the eventual harvest of fresh fruits and vegetables often ending up on the menu at The Land's and other EPCOT Center restaurants.

Plant scientist Alexandra McKently, program coordinator for the biotechnology laboratory, is working with researchers at the University of Florida to develop methods of incorporating genes for favorable traits into peanuts.

"This research is just one of many ways that scientists are working to improve the quality of products available to the consumer," she says.

Robitaille believes the more the general public understands about plant biotechnology, the more comfortable they will be with the idea. He considers EPCOT Center an ideal location for earning the public's understanding and support because people are highly receptive to new information while they are being entertained, he says.

Officials from ARS and Kraft, which sponsors The Land and financially supports its research, are excited by the idea of communicating biotechnology to the public.

"It's the unknown that scares people," says Jerome P. Miksche, ARS national program leader for plant physiology, who helped develop the concept of a public biotechnology lab. "Exposing millions of people to biotechnology at this exhibit will go a long way toward demystifying genetic engineering and allaying people's concerns."

ARS provided most of the laboratory's equipment, including laminar flow hoods, shaker tables, glassware, microscopes, and cameras, as well as some technical expertise.

A goal of Robitaille's is to attract young people to consider careers in the agricultural sciences. He hopes the laboratory sparks the interests of its younger visitors.

The Land does have information to help students who write about possible science projects. "It isn't difficult for students to do tissue culture on a small scale at school or even at home," he says.

Visitors can even take home their own little bit of biotechnology with "Teenie Greenies." Tiny cloned strawberry, pineapple, and potato plantlets packaged in plastic vials, complete with growing-at-home instructions, are available in The Land's souvenir shop.—By **J. Kim Kaplan,** ARS.

Jerome P. Miksche is USDA-ARS national program leader for plant physiology research, Bldg. 005, BARC-West, Beltsville, MD 20705 (301) 344-2029. ◆

BARRY FITZGERALD

BARRY FITZGERALD

BARRY FITZGERALD

Top to bottom: Student intern Connie Rowinski (left) and plant scientist Alexandra McKently work to improve the genetic composition of peanuts. A small video camera allows guests on the boat ride to observe the work. (89CN1523-32) **While EPCOT Center guests observe the biotechnology laboratory along the Listen to the Land boat ride, plant scientist Alexandra McKently examines a tissue culture vial.** (89CN1529A)
"Scientist" Mickey admires tissue-cultured plants available for sale in EPCOT Center. (89CN1527-3A)

Better Tasting, More Healthful Oils

KEITH WELLER

Oils from a wide variety of grains and oilseeds are evaluated at ARS' Northern Regional Research Center in Peoria, Illinois. (K-3246-19)

Consider the case of soybean oil, a product which held a minor market niche 50 years ago. Today it's the major edible oil in the United States, thanks largely to research on preserving its flavor and storability.

And thanks to genetic engineering of plants and highly sophisticated new analytical methods, improved vegetable oils promise to continue pouring forth from lab to market-place, says Agricultural Research Service chemist Timothy Mounts at the Northern Regional Research Center, Peoria, Illinois.

Already, plant breeding has helped propel two newer oilseed crops—sunflower and canola—to expanding markets. Sunflowers have been bred to produce oils that withstand higher cooking temperatures by increasing their oleic acid. And the erucic acid in canola has been lowered to make the oil more healthful. Higher concentrations of erucic acid are suspected of causing heart damage.

In recent years, researchers have developed soybean breeding lines that may be forerunners of varieties specially suited for making salad oils. These oils could be stored at room temperatures without noticeable flavor deterioration 2 to 3 months longer than ordinary soy oils.

Learning how to improve soy oil for health-conscious consumers may benefit the entire oilseed industry.

"Our studies on soy oil include comparisons with other vegetable oils, so what we learn could prove useful to the newer sunflower and canola oil industries," says Mounts.

For example, in a recent study on soybean, sunflower, and canola oils, food technologist Kathleen Warner reported that storage conditions influence deterioration in each oil differently.

When these oils were kept in darkness and aged rapidly at 140°F, soy oil resisted breakdown best. With help from an additive, citric acid, both canola and sunflower oil resisted breakdown by light more effectively than did soy oil. Without citric acid, canola oil was less stable in light than either sunflower or soy oil.

Getting Away From Off-Flavors

In the mid-1980's, Warner and chemist Edwin N. Frankel discovered that flavor deterioration of soy oil exposed to light could be reduced by adding as little as 5 parts per million betacarotene, a natural food color and vitamin A precursor, to the oil. That's less than 5 one-thousandths of a gram in a 32-ounce bottle of oil.

During the 1940's, the Center's first significant research to help the fledgling soybean oil industry was development of standardized equipment to process oils that were to be assessed for flavor and odor by sensory panelists.

In research using this equipment, USDA scientists identified the susceptibility of soybean oil to deterioration caused by oxygen and by trace metals—as little as 0.3 ppm iron or 0.1 ppm of copper. The processing industry responded by removing brass valves in refineries and blanketing oils with an inert gas—nitrogen—in high-temperature phases of processing and in packaging.

Trace metals, minor constituents such as pigments, and the molecular structure of sunflower, canola, and soybean oils may account for differences in oil stability. As the causes are identified, research should help plant breeders and processors tailor each of the oils for specific food uses such as deep frying oils, margarines, salad dressings.

Also during the 1940's, scientists at the Center found that off-flavors and objectionable odors that develop

KEITH WELLER

To determine the frying and baking performance of low-linolenic acid soybean oils, food technologist Kathleen Warner (emptying deep fryer) and technician Linda Parrott conduct studies to compare genetically modified oils with commercial products. (K-3247-17)

in aging soybean oil are mostly associated with the breakdown of linolenic acid.

Breeding for Low Linolenic Acid

One way to tailor soybean oil for salad dressings and cooking oils with a long shelf life is to breed soybeans with low linolenic acid content. To that end, ARS plant geneticist James R. Wilcox, West Lafayette, Indiana, first genetically altered soybean seeds by treating them with a chemical that caused them to mutate. Then he selected offspring with genes for low linolenic acid production to form a breeding line called C1640.

In contrast to 8 percent linolenic acid in conventional soybean varieties, C1640 contains about 4 percent. By further breeding C1640 with the higher yielding Century, Wilcox has developed lines with linolenic acid content similar to C1640 and yield that is similar to Century, one of the most popular commercial varieties in the mid-1970's.

Plant breeding has helped propel two newer oilseed crops, sunflower and canola, to expanding markets.

Such soybeans could offer processors an opportunity to produce stable cooking oils without the added 3- to 5-cent-per-pound cost of partial hydrogenation, says Mounts. Hydrogenating, or combining vegetable oils with hydrogen, also reduces linolenic acid content of the oils.

Processors might expect at least a 15-percent higher yield of dual-purpose cooking/salad oil from the new soybeans than they're now getting from conventional varieties, says Mounts, by not partially hydrogenating oil from the new beans.

In finishing oil, processors slowly cool it, solidifying some of the more hydrogen-saturated fats that must be removed to meet commercial standards. The removed fats are generally used to make shortenings.

Another approach to genetically modifying soybeans to preserve oil freshness is to breed them to have little or none of the enzyme that breaks down linolenic acid.

To inactivate the responsible enzyme—lipoxygenase—commercial processors now temper whole soybeans with heat, a process that is expensive and that decreases the amounts of oil and purified protein that can be obtained from the beans.

KEITH WELLER

The ultimate measure of an oil's quality is the flavor of foods fried in it. Working under red lights, which preclude visual comparisons, sensory panelists taste fried foods and enter their ratings into a computer terminal. (K-3247-12)

University of Illinois plant geneticist Theodore Hymowitz was first to identify soybeans lacking a form of lipoxygenase (L1). In collaborative studies with nutritionist Barbara P. Klein, also of the university, Frankel and Warner compared flavor qualities of oil and meal in breeding lines developed from these soybeans with normal soybeans and found no differences. The lack of differences may have stemmed from significant amounts of other forms of lipoxygenase called L2 and L3, Frankel says.

To identify soybeans lacking L1, L2, or L3, ARS geneticist Niels C. Nielsen and his colleagues at Purdue University, West Lafayette, Indiana, developed a screening process and applied it to nearly 3,000 strains from the U.S. Soybean Germplasm Collections at Urbana, Illinois, and Stoneville, Mississippi. This study led to one null L2—devoid of the L2 enzyme—and several null L3 and L1 lines.

Soymilk made from full-fat flour of the null L2 line has fared well in flavor and aroma tests conducted by Kansas State University's Sensory Evaluation Laboratory, Manhattan, Kansas. Soymilk from a cross of the null L2 and L3 lines tasted even better.

"The studies have generated considerable commercial interest," Nielsen says. This summer, farmers in Indiana and Ohio are being paid a premium to grow nearly 4,000 acres of the L2 nulls. The beans will be used to test export market potential in Japan as part of a collaborative project by Purdue University, ARS, and a major soy processing company.

Oilseed Varieties Made to Order

As plant breeders and genetic engineers begin tailoring oilseed varieties for certain qualities, Mounts foresees a major impact on the marketing system for soybeans. He says processors may develop contracts with farmers to plant the specific variety to provide desired end use properties.

ARS plant physiologist Richard F. Wilson, Raleigh, North Carolina, has conducted biochemical studies that led to soybeans bred for varying fatty acid composition (see *Agricultural Research,* Nov/Dec 1987). One strain is low in palmitic acid—a highly saturated fatty acid suspected of contributing to blood serum cholesterol. Some breeding lines are low in linolenic acid, and still others are high in oleic acid that stands up well to high cooking temperatures.

As soy or other vegetable oils are used repeatedly in deep-fat frying, fatty acids may combine with oxygen at high temperatures to eventually produce more and more objectionable odors and flavors.

Frankel, who has been studying this problem, says heat forms compounds called cyclic monomers and polar materials in fried foods, and it may also damage nutritional value. Much remains to be understood about some of the compounds' presumed health effects, both harmful and beneficial.


KEITH WELLER

Vegetable oil research leader Tim Mounts examines salad/cooking oil prepared from crude oil extracted from genetically modified soybeans. (K-3247-7)

Other research at Peoria focuses on volatile compounds that form from vegetable oils not only during heating but also as they age. Chemist Janet M. Snyder has developed gas chromatographic analytical procedures to relate these compounds to changes in flavor.

Frankel and Snyder have also developed a rapid near infrared method to analyze beans and crude soybean oil for free fatty acids formed during postharvest handling and storage. This procedure may become useful for screening beans for quality as they enter domestic and foreign markets.

Warner and her colleagues have found that the flavors of crude oils provide the most reliable prediction on the keeping quality of fully processed oils. But crude oil has an overwhelmingly strong flavor, she says, and must be diluted with good-quality finished oil to enable sensory panelists to best detect quality differences. She has found that the best dilution rate is 1 part crude oil to 19 parts finished oil.

The quality of crude oils varies according to geographical origin of the seed, postharvest handling and storage history, the time of year, and the processing conditions before and during extraction from the crushed oilseed.

"We've developed sensitive and reliable methods to evaluate vegetable oils," says Mounts. "Now we feel we're ready to make further progress to help genetic engineers, plant breeders, farmers, and food processors make a coordinated effort at improving products for domestic and export markets."—By **Ben Hardin,** ARS.

If you're interested in contacting scientists mentioned in this article, write or telephone the author, Ben Hardin, 1815 North University St., Peoria, IL 61604 (309) 685-4011. ◆

Pastures Need Help for Clean Bill of Health

Livestock pasturing has been singled out recently as a suspected source of groundwater pollution.

This concern could be valid in some cases, says soil scientist Lloyd B. Owens. He notes that if plants don't take up fertilizers placed on pastures, these chemical compounds may leach down into the groundwater below.

Owens, who is with the Agricultural Research Service in Coshocton, Ohio, has conducted tests on four areas of northern Ohio since 1979. These include pastures with different fertilizer application rates and differing numbers of cattle being grazed.

"A unique feature of our test pastures is an impervious layer of clay a few feet underground that prevents water from penetrating. That means the groundwater doesn't sink deeply but instead follows the contour of the land downhill like an underground stream," he says. "We simply sample the water coming off the pastures from springs at the bottom of the watersheds."

At the beginning of these tests, researchers wanted to get some idea of what impact a soluble chemical such as nitrogen fertilizer might have on groundwater. They also wondered how well the springs would work to monitor groundwater.

They made a heavy, one-time application of the chemical potassium bromide (150 pounds per acre) to two of the pastures. This chemical can be used as a tracer because soil normally has only miniscule amounts of bromide ions. Thus, bromide ions detected in the groundwater almost certainly came from the chemical applied to the surface.

Since bromide ions move through soil at a speed similar to that of nitrate ions, they can be used as a gauge of how nitrogen fertilizer would move. If the tests were run with a nitrogen fertilizer, results could be confused with nitrates already in the soil.

"Even though there was only one application of potassium bromide, bromide ions were detected in the groundwater for the entire 5-year study. This demonstrates the fact that if you apply more soluble material, such as a nitrogen fertilizer, than the plants can use, residues will be in the groundwater for several years," says Owens.

"We recommend that farmers overseed winter pastures in the spring to keep the grass cover and to slow erosion and water pollution."

Lloyd B. Owens, soil scientist

In another 5-year study, a moderate amount of nitrogen fertilizer (50 pounds per acre a year) was applied to four watersheds. A spring-calving herd of beef cows was grazed on the four pastures rotationally. One of the four was used for winter grazing supplemented by hay.

Throughout 5 years of testing, nitrates never exceeded the Environmental Protection Agency's standard for safe drinking water, 10 parts per million of nitrates.

However, the problem may be a cumulative one: "Since the concentration of nitrates in the water from the pasture used for winter grazing and supplemental feeding increased every year of the test, there might eventually be a problem of high rates of nitrates in the groundwater," Owens says.

Farmers may have to discontinue winter feeding in the field area, or lower or discontinue fertilization for a while to maintain groundwater quality, he says.

By the end of another concurrent 5-year, high-fertility (200 pounds per acre a year) study, concentrations of nitrates in groundwater from summer-grazed pastures were near the 10-ppm limit and those from the pasture used for winter grazing exceeded it by 2 ppm.

Owens says, "This is too high. In contrast, surface runoff, which was also checked in all our tests, on the average contained nitrates well below the 10-ppm limit in both the low and high fertilized pastures." In the pastures used for winter grazing, groundwater and surface runoff contained more nitrates than areas grazed in the summer only. This was caused by cattle damaging the sod during high-moisture, low-growth late fall and winter seasons.

"We recommend that farmers overseed winter pastures in the spring to keep the grass cover and to slow erosion and water pollution," says Owens.

To further limit ground and runoff water pollution, Owens would also suggest that farmers split their fertilizing between early spring and late spring or early summer.

In the eastern part of the country, pastures are fertilized to support the maximum number of cattle to make farming profitable. Too much nitrogen fertilizer can pollute streams and groundwater. Owens' tests show that with proper use of fertilizer and rotational grazing of pastures, drinking water can be kept safe.—By **Vincent Mazzola,** ARS.

Lloyd B. Owens is at the USDA-ARS North Appalachian Experimental Watershed, P.O. Box 478, Coshocton, OH 43812 (614) 545-6349. ◆

Mutant Pea Glutton for Iron

A suicidal pea plant could play a key role in boosting the nutritional quality of the typical American diet.

The pea plant, E107, doesn't know when to stop taking up iron from the soil and will eventually accumulate deadly levels of the element.

While this is bad news for E107, it could be good news for the American consumer, according to Ross M. Welch, a plant physiologist with the Agricultural Research Service.

"We'd love to get more iron into the edible parts of plants," says Welch. "For some population groups in this country, our diet is short on iron. This plant could help show us ways we might increase the iron content in crops."

Soil contains iron in many forms, including ferric and ferrous iron. Plant roots can't take up ferric iron, but they can use the more soluble ferrous iron.

In the normal scheme of nature, plant roots can transfer an electron to ferric iron, transforming it to ferrous iron. In addition, plant roots excrete hydrogen ions that make the soil more acid and render insoluble forms of ferric iron more soluble.

Typically, when a plant gets enough iron to satisfy its needs, it shuts down its electron transfer process and hydrogen ion excretion. But E107 never stops, Welch says.

"If you limit the iron available to the mutant, it grows normally," he says. "But on most normal soils, it will kill itself."

E107 first surfaced in studies conducted by Tom Larue at the Boyce Thompson Institute at Ithaca, New York. It was obvious from the start that something was strange about E107: As the plant's leaves aged, they turned a peculiar bronze tint and died.

Sorting out the reasons behind the plant's odd appearance proved to be a puzzle worthy of the efforts of a whole team of ARS scientists, led by plant physiologists Welch and Leon V. Kochian and soil scientist David L. Grunes at ARS' U.S. Plant, Soil, and Nutrition Research Laboratory at Ithaca.

Mutant pea plant on right is killing itself with iron even though growing in normal levels of the element. (K-3291-1)

Welch says E107 differs from the commercial pea variety Sparkle by only one gene, and researchers even know which gene this is.

"Within the next 2 years, we should finish characterizing the physiology of the mutant," he says. "Then we want to compare the normal plant with the mutant and see what that one gene does in the normal plant."

The work may also provide some insights into idiopathic hemochromatosis, a genetic disorder in humans. Victims of this disorder accumulate too much iron, even when consuming a normal diet. If left untreated, the condition leads to liver damage and eventually death.

"The cell membrane in plants is not a lot different from the cell membrane in people," Welch notes. "Researchers have been working on idiopathic hemochromatosis for 50 years and still don't know the metabolic defect. If our studies with the mutant pea plant tell us what regulates transport of iron across cell membranes, the information could be very useful in finding ways to prevent or treat this human disorder."—By **Sandy Miller Hays**, ARS.

Ross M. Welch is at the U.S. Plant, Soil, and Nutrition Laboratory, Tower Road, Ithaca, NY 14853 (607) 255-5434. ◆

Smelling Just Peachy Keen

While a rose by any other name may smell as sweet, a peach doesn't always smell as peachy as it might.

Ferreting out what it is in a sweet, tree-ripened peach that makes it smell so mouth-watering good and why a store-bought peach can smell so much less peachy has been a goal of Agricultural Research Service chemists Robert J. Horvat, James A. Robertson, and Glenn W. Chapman, Jr. They are part of the Horticultural Crops Quality Research Laboratory in Athens, Georgia.

"We've identified five specific compounds from tree-ripened fruit that, mixed together in the right quantities, are essential to create what our smell panelists call the peach odor," says Horvat.

These peach-smelling compounds are two 6-carbon aldehydes, a terpene, linalool, and gamma-decalactone, a 10-carbon lactone, each present in quantities measured only in parts per billion.

The smell panels were informal, but they were made up of people who deal with odor chemistry. "And they worked from the freshest possible peaches," Horvat says. "For them to get the best peach smell, we found the peach really had to be less than 4 hours from the tree."

After even just 4 hours, they were able to smell differences from the ideal aroma.

But commercially, most peaches must be picked a little on the green side so they can be shipped to market before they get overly soft.

When the researchers looked at peaches shipped this way, they found a totally different profile for the five essential aroma compounds.

"It wasn't so much that any were missing as they were in a different combination of concentrations," Horvat says. "In particular, there was a much lower concentration of the two aldehydes."

Now that Horvat has isolated what the essential compounds are in

peaches as far as aroma, he hopes to pin down the point at which peaches on the tree start approaching that profile.

Eventually he hopes to make recommendations for when peaches should be picked for the best compromise between shelf life and aroma.

But for real peach aficionados, the only way to get a perfect-smelling peach may be a peach tree in the backyard.—By **J. Kim Kaplan,** ARS.

Robert J. Horvat is in the USDA-ARS Horticultural Crops Quality Research Laboratory, P.O. Box 5677, Athens, GA 30613 (404) 546-3319. ◆

Patents

No-Calorie Flour

Chocolate cupcakes with less guilt? That possibility is within grasp—and bite—as two companies prepare to produce a no-calorie, high-fiber flour from a recipe stirred up by Agricultural Research Service scientists.

Du Pont Co., of Wilmington, Delaware, and Mt. Pulaski Products, Inc., of Mt. Pulaski, Illinois, have been licensed to produce the dietary fiber by a process patented by chemist J. Michael Gould and biologist Lee B. Dexter, both of the Agricultural Research Service's Northern Regional Research Center in Peoria, Illinois.

The companies expect to sell the flour to firms making fiber-rich bread, cookies, cakes, crackers, doughnuts, and other foods.

Fiber-rich breads, waffles, and muffins are just the beginning, says J. Michael Gould. His fiber-flour invention may also appear in doughnuts, cakes, cookies, and other prepared foods. (K-3199-12)

Du Pont will use the process to manufacture white oat fiber from oat hulls. Mt. Pulaski Products will produce a flour from the filmy outer portion of corncobs.

"In both cases, the activity involved is essentially the same," Gould says. "The process softens the fibrous parts of cereal crops so they can be ground and used as a no-calorie, high-fiber product."

The flour is made by using a dilute solution of hydrogen peroxide to break down the lignin in plant materials. Lignin is a cement that binds plant cell walls.

A taste panel and other tests found the flour could boost the fiber content of baked goods such as pancake and cake mixes by up to 30 percent without affecting taste.

"And the fiber doesn't add calories," Gould says. "We found we could make a white bread that looks, feels, and tastes like any other white bread but which has as much dietary fiber as whole-wheat bread and fewer calories than other white bread."

Canadian Harvest USA, a joint partnership of Du Pont and ConAgra, Inc., of Omaha, Nebraska, will produce the oat fiber from a factory nearing completion in Cambridge, Minnesota. The company expects to begin selling the flour to food producers later this year.

Mt. Pulaski Products, in central Illinois, is scheduled to start production of its corn fiber flour within the next few months. The firm will be buying corncobs in a 60- to 100-mile radius of Mt. Pulaski, adding an estimated $5 million to the rural economy.

"These two firms demonstrate what our research is really all about," Gould says. "We developed a product that's now out of the lab and into commercialization, where it will not only provide a product for consumers but will generate jobs and stimulate local economies. "That type of technology transfer is what we are trying to accomplish."—By **Matt Bosisio,** ARS.

For technical information, contact J. Michael Gould, USDA-ARS Biopolymer Research, Northern Regional Research Center, 1815 N. University St., Peoria, IL 61604 (309) 685-4011. U.S. Patent No. 4,774,098 "Modified Plant Fiber Additive for Food Formulations." ◆

Letters

*We invite letters from readers and, from time to time, will share them in this column.—**Ed.***

On the June Issue: As a past president of the American Society of Plant Physiologists (1951-52) and a former director of research in ARS (1955-71), I am indeed delighted with the June '89 issue of *Agricultural Research*. The commentary on the very excellent studies underway in plant physiology in ARS delighted me no end.

Cecil H. Wadleigh
Lanham, Maryland

Dr. Wadleigh retired from ARS in 1971. He is a member of the agency's Science Hall of Fame.

On Infant Nutrition: Thank you for the cover on the June 1989 issue of *Agricultural Research*. Your tasteful display of the nursing mother is most appreciated.... Your choice of photos shows that breastfeeding can be done discreetly and that a mother can wear regular clothing. When more people learn that breastfeeding can be done in a normal, discreet setting, they will be more accepting of this type feeding.

Susan A. Young
Walterboro, South Carolina

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